BIOLOGICAL EVALUATION
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EVALUATION OF DOUGLAS-FIR BEETLE ALONG THE NORTH FORK OF THE SHOSHONE RIVER, SHOSHONE NATIONAL FOREST, WYOMING

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PREPARED BY:

Kurt K. Allen
Entomologist
Rapid City Service Center

PREPARED BY:

Daniel F. Long
Forest Health Technician
Rapid City Service Center

APPROVED BY:

Frank J. Cross
Group Leader
Forest Health Management

Renewable Resources
USDA Forest Service
Rocky Mountain Region
740 Simms Street
Golden, CO 80401

ABSTRACT

Douglas-fir beetle (*Dendroctonus pseudotsugae*) infestations frequently result from disturbance events that create large volumes of weakened Douglas-fir (*Pseudotsuga menziesii*) trees. In 1988, extensive wildfires occurred in Yellowstone National Park and the Shoshone National Forest. Populations of Douglas-fir beetle increased in fire-scorched trees caused by the wildfires. Subsequent generations of the beetles moved from these injured trees to undamaged trees in neighboring stands on the Shoshone National Forest, Wyoming.

This outbreak has now moved and is concentrated along the North Fork of the Shoshone River. Beetle populations continue to build and continued high levels of mortality can be expected along the North Fork.

Continued use of sanitation harvest and anti-aggregation pheromones, where possible is recommended.

INTRODUCTION

The Douglas-fir beetle (*Dendroctonus pseudotsugae* Hopkins) infests and kills Douglas-fir (*Pseudotsuga menziesii*) throughout its range in North America. Typically, the beetle reproduces in scattered trees that are highly stressed, such as windfall, defoliated or fire-scorched trees (Furniss, 1962; Furniss, 1965; Lessard and Schmid, 1990). If enough suitable host material is present, beetles can increase in the stressed trees and infest nearby healthy trees (Furniss et al., 1981). Previous research on Douglas-fir beetle infestations have examined forest stand and site characteristics associated with infestations (Furniss et al., 1979; Furniss et al., 1981; Weatherby and Thier, 1993; Negron, 1998), and developed models to predict the extent of tree mortality (Negron et al., 1999). For example, Douglas-fir beetle attacks are most successful on trees that are mature or overmature, largest in diameter, and found in high density stands that contain a high percentage of Douglas-fir in the overstory (Schmitz and Gibson, 1996).

The Douglas-fir beetle has one generation per year (Schmitz and Gibson, 1996). Although adult flight times vary by year, most new attacks occur in late spring to early summer on the Shoshone National Forest. Broods develop under the bark throughout the summer and early fall. The overwintering lifestage can be as adults, pupae or larvae. Larvae that overwinter emerge as adults in the summer. A small percentage of adults that overwintered will re-emerge from the spring-attacked trees and attack additional trees in the middle of the summer.

Fires that started in Yellowstone National Park in 1988 burned onto the Clarks Fork Ranger District of the Shoshone National Forest, Wyoming, killing and scorching a large number of trees. Populations of the Douglas-fir beetle increased in scorched trees and began attacking neighboring green trees in this area (Pasek, 1990). Similar events took place within Yellowstone National Park (Rasmussen et al., 1996). This Douglas-fir beetle infestation has obviously impacted forest stand conditions over the last decade (McMillin and Allen 2000). Changes in beetle populations were estimated (Pasek, 1990, 1991; Pasek, 1996; Pasek and Schaupp, 1992, 1995; Schaupp and Pasek, 1993, 1995; Allen and Pasek, 1996) and a predictive model was developed based on the mortality that occurred in the early to mid 1990's (Negron et al., 1999), additional mortality has occurred since the last measurement of mortality in 1995. Much of this additional mortality has occurred along the North Fork of the Shoshone River. This is a highly visible area, leading to the east gate of Yellowstone National Park. Over the last 2 years, some small sanitation efforts to remove infested trees occurred in campgrounds along this stretch. Also, use of MCH (3-methylcyclohex-2-en-1-one), an anti-aggregation pheromone, was used to protect uninfested trees in high value areas. This technique has been shown to be highly effective at reducing tree mortality (Ross and Daterman 1994, 1995).

METHODS AND MATERIALS

One method of determining infestation level trends is through use of aerial detection surveys. These surveys can only detect trees killed the previous year and can't be used as methods to predict population trends overall, but can at least present a picture. During the years since the Clover Mist Fire, aerial surveys have been done in this area to get estimates of tree mortality.

On September 12, 2001, 6 inch by 6 inch bark samples were removed from the north and south sides of currently infested Douglas-fir trees. Samples were taken at DBH. Samples were taken from along the North Fork of the Shoshone River. One sample area was near the Buffalo Bill Boy Scout Camp, where 17 trees were sampled and the other was across the river from Eagle Creek Campground, where 20 trees were sampled. Diameter at breast height was recorded for each sample tree. Bark samples were put into plastic bags, along with any live Douglas-fir beetle or DFB enemies, and brought back to the lab for examination. The measurements taken for each sample included: Number and life stage of live DFB, number of gallery starts, inches of egg gallery, and number of each of three natural enemies of DFB (Clerids, *Coeloides*, and *Medetera*).

RESULTS AND DISCUSSION

Table 1 shows the amount of mortality caused by Douglas-fir beetle that has been detected over the last 10 years. Most of the mortality early on was found in the Clarks Fork and Sunlight Basin areas, while the last 4-5 years mortality has been concentrated along the North Fork.

Table 1. Tree mortality caused by Douglas-fir beetle on the Clarks Fork Ranger District, Shoshone National Forest, based on aerial detection surveys.

Year	No. Acres Infested	No. Trees Killed	Timber Volume Killed ($ft.^3$)
1992	2,324	5,585	309,130
1993	1,559	4,113	227,656
1994	2,481	5,115	283,115
1995	1,723	4,542	251,400
1996	1,271	1,075	59,501
1997	1,203	989	54,741
1998*	2,383	1,680	92,988
1999	5,791	14,449	799,752
2000	7,636	25,971	1,437,494
2001	11,575	15,604	863,681

*Prior to 1998, most mortality occurred in the Clarks Fork/Sunlight Basin. Starting in 1998, the infestation moved and most of the mortality occurred along the North Fork of the Shoshone River.

Brood sampling was done on a total of 37 trees, with a sample taken from both the north and south side of each tree. Two sample sites were used, the Boy Scout camp (17 trees) and across the river from Eagle Creek Campground (20 trees). There was no difference between north and south samples, and so those numbers have been combined.

Average tree diameter at the Boy Scout site was 20.8 inches. There were 589 live DFB brood found in the samples taken, of these, 584 were new adults and 5 were pupae. This means there was an average of 17.3 live brood per sample. The average number of gallery starts per sample 1.5. There was an average of 15.5 inches of egg gallery per sample. There were a total of 17 natural enemies found in the 34 samples, 7 wasps (*Coeloides*) and 10 flies (*Medetera*).

Population trends can be estimated by dividing the density of emerging beetles by twice the density of gallery starts (attacks), assuming that a pair of beetles initiates each gallery start. When the ratio of emergence to attack exceeds one, the population is increasing and when the ratio is less than one the population is decreasing. The ratio at the Boy Scout is 5.8:1 for emerging to attacking, indicating that the population is in fact still increasing strongly.

Average tree diameter at Eagle Creek 16.7 inches. There were a total of 496 live DFB brood found in samples taken, of these, 490 were new adults and 6 were larvae. The average brood per sample was 12.4. The acreage number of gallery starts per sample was 1.7 and the average length of egg gallery per sample was 21.2. There were a total of 91 natural enemies found at this site, 78 *Coeloides* and 13 *Medetera*.

The population ratio at Eagle Creek was 3.6:1 for emerging to attacking beetles. Again, this indicates an increasing population in this area.

Maximum brood production takes place when gallery starts average between 1 and 2 per 6”x6” sample (McMullen and Atkins 1961). This is the case for both sample sites, giving another indication that beetles are producing offspring at a high rate and the population is increasing.

Maximum brood production can also be measured by the amount of gallery length produced. Maximum production takes place when there is 7.5 to 15 inches of gallery per 6”x6” sample (McMullen and Atkins 1961). The averages for these sites were 15.5 and 21.2, which are slightly above those numbers.

CONCLUSIONS AND RECOMMENDATIONS

If no management actions are implemented while the Douglas-fir beetle outbreak continues, there will be further reductions in overstory basal area and average tree diameter across the landscape. Based on the levels of mortality that have occurred to date, managers can expect to lose between and 40 and 70 percent of the Douglas-fir basal areas in areas of heavy tree mortality. In addition, the average size of trees will be reduced

in the short-term. Regeneration and forage production will increase in beetle-caused openings in the forest. The majority of the regeneration should continue to be Douglas-fir and smaller percentages of spruce, fir, and pine.

For areas of the forest where control of Douglas-fir beetle is warranted, current management strategies include:

Salvage/sanitation harvesting

Sanitation harvesting involves removing currently infested trees from the site. Removal of these infested can decrease a localized beetle population. Sanitation harvesting should be completed before the beetles start to emerge in May of each year. In addition, in stands that have been heavily attacked and mortality has been high, salvaging dead trees to capture some economic value in the near future is appropriate. However, salvage harvesting does not reduce beetle populations. This action will depend on management objectives for each area.

Anti-aggregation pheromones (MCH)

Douglas-fir beetle has a well-studied complex of pheromones (message-bearing chemicals), which it emits to regulate the behavior of other beetles. Anti-aggregation pheromones, such as MCH, serve to disrupt aggregation behavior of beetles (Schmitz and Gibson, 1996). MCH has been used experimentally to reduce the level of attack in high-risk areas (Ross and Daterman, 1994, 1995). Tables 2 and 3 below, list the high value areas and the needed amount of MCH to provide for tree protection. In addition, the use of MCH can be combined with aggregation pheromones that are attached to funnel traps located outside areas of high value to reduce beetle population. Another alternative is to concentrate attacks on certain trees by using the aggregation pheromones and the remove those trees (i.e., trap tree method), thereby lowering the beetle population in a localized area.

Table 2. Size, number of MCH capsules needed, and approximate cost of MCH for prevention of campgrounds susceptible to infestation by Douglas-fir beetle.

Campground	Size in acres	MCH capsules
Newton Creek	25	625
Eagle Creek	9	225
Clearwater	5	125
Total	**39**	**975**

Table 3. Size, number of MCH capsules needed, and approximate cost of MCH for prevention of US Forest Service permittees susceptible to infestation by Douglas-fir beetle.

Campground	Size in acres	MCH capsules
Pahaska Tepee Lodge	23	575
Shoshone Lodge	6	150
Crossed Sabers Lodge	20	500
Goff Creek Lodge	3.7	92
Elephant Head Lodge	3.6	90
Absaroka Mt Lodge	6.3	157
Blackwater Ranch	10.5	262
UXU Ranch	34	850
BSA Camp Buffalo Bill	59.7	1,492
Total	**166.8**	**4,168**

Silvicultural treatment

Being that Douglas-fir beetle attacks are most successful in unmanaged, overstocked stands that contain a high percentage of large diameter Douglas-fir, silvicultural treatments that alter these stand conditions will reduce a stand's susceptibility to attack and potential wide-spread damage. Silvicultural treatments are used in stands that have not yet been affected by the beetle to reduce susceptibility to attack. It should be part of an ongoing vegetation management program to help increase the health of stands by decreasing their vulnerability to any insects and diseases, not just Douglas-fir beetle. To reduce the susceptibility of stands to Douglas-fir beetle, basal area should be below 80% of normal stocking (Furniss et al. 1981). Harvesting in old, mature stands and thinning younger stands could be used to create healthier stand conditions where it is appropriate.

No action

The no action alternative represents taking no management actions in the Douglas-fir beetle impacted areas outside of normal activities. It accepts present and possible future tree mortality as a natural process. Tree resistance, natural enemies, such as parasitic and predacious insects and other invertebrates, and loss of suitable host trees will help to collapse the Douglas-fir beetle populations over time.

Our recommendation is the use of anti-aggregation pheromones and sanitation harvest of green infested trees to protect high value areas at this time. This is going to be a continuing process, as it appears the beetle population is still expending and may continue to cause significant amounts of mortality over the next few years. Also, it is appropriate to look at larger, landscape level projects for the future. Many areas along the North Fork have undergone significant change and many more are still at risk. Having a sound management plan for this area will only help to provide for the

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